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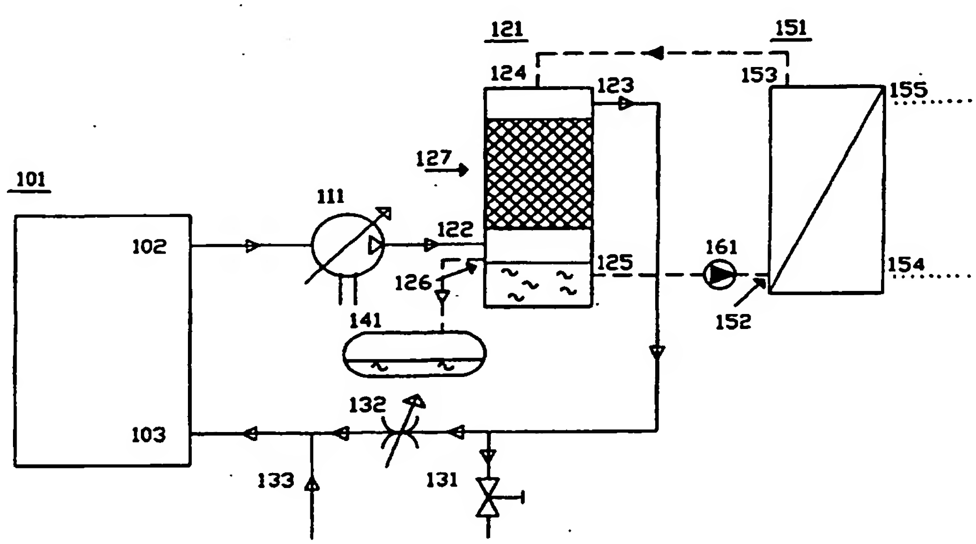

(57) Abstract

A process for controlling the composting air in a composting system, which comprises an aerobic composting reactor (101), consists of the following steps. The composting air is sucked out of the composting reactor (101), is pressed into an air washer (121), which cools the composting air with washing water, and then part of the composting air is withdrawn and the rest of the composting air is throttled, is mixed with fresh air and is recirculated to the composting reactor (101). This control ensures a very high degradation rate by controlling the supply of oxygen for the composting and the water content in the organic material, which results in a considerable generation of composting heat and evaporation of ammonia. The composting heat is transferred to a heating system via a heat exchanger and the ammonia is collected and used as a soil conditioner.

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Plant and method for cleaning and cooling of recirculated air during composting and use of such a plant or method

The invention concerns a process for controlling the composting air in a composting system for aerobic degradation of organic material, a composting system for use in the performance of the process, and use of the composting system and the process to collect ammonia and to utilize the composting energy.

Composting is an aerobic biological process where microorganisms degrade dry matter primarily to carbon dioxide, water and heat (about 17 MJ/kg of degraded dry matter). The degradation releases a considerable part of the nitrogen content in the organic material as gaseous ammonia. By a high dry matter degradation rate it is possible to transform a large amount of organic material into compost in a short time and to obtain a considerable generation of heat and evaporation of ammonia.

The prerequisite for a high degradation rate is that the microorganisms have favourable living conditions. It is generally known that aerobic microorganisms require a moist environment, supply of oxygen and removal of the composting products water, heat and carbon dioxide. The requirements with respect to the living conditions of the microorganisms involve a conflict between having a high content of water and oxygen at the same time.

This problem is solved for solid organic material by creating an airy structure in the organic material, while having a low content of dry matter with respect to water. For manure mixed with straw a dry matter content of about 25 % is optimum. At a higher dry matter content the lack of water will impede the process. At a lower dry matter content the bulk density of the manure will be so high

that the dead weight presses the manure together, and lack of oxygen occurs quickly. It is usual to regulate the dry matter content in the organic material prior to composting, but to obtain a high degradation rate it is necessary that the dry matter content is efficiently regulated during composting.

The other essential prerequisite for a high degradation rate is a uniform and regular supply of oxygen to the organic material during composting. This is ensured by composting in a composting reactor, which is a container with composting air control. When the composting air flows through the organic material, the microorganisms absorb oxygen from the air, and the content of carbon dioxide, water and ammonia in the composting air increases. The exit air from the composting reactor is about 60 ^{o}C, contains ammonia and is saturated with water vapour.

The possible content of water vapour in the composting air depends on the pressure and temperature of the air. Control of the pressure, temperature and oxygen-content of the composting air enables regulation of the dry matter content in the organic material as well as the supply of oxygen during composting. The result of this regulation will be an extremely high degradation rate.

The energy in the composting air is primarily bound in water vapour, and condensation of the water vapour releases about 2.3 MJ/kg of condensed water vapour. The water vapour in the composting air may be condensed by cooling and by compression. Use is made of the fact that the ability of saturated air to contain water vapour is halved by isobaric cooling of about 11 ^{o}C or by isothermal compression which doubles the absolute pressure.

It is generally known to use an air washer to cool air. The air washer consists of a vertical pipe which is filled with a washing material. The washing material has a large surface and a low counterpressure for blowing of air. The air washer operates according to the counterflow principle, as the washing water trickles down through the washing material and cools the air which is blown up through the washing material. This type of air washer has previously been used in a composting system comprising a composting reactor to transfer energy from the exit air of the system to a heating system. A heating system uses heat energy e.g. for space heating and hot service water.

Condensing at a high pressure is one of the basic principles of heat pump systems. A heat pump is a circuit which consists of evaporator, compressor, condenser and throttle valve. A working medium circulates in the circuit and transfers energy from evaporator to condenser. This takes place as a consequence of a low pressure in the evaporator which causes the working medium to evaporate, following which the vapour is condensed, and the high pressure causes the working medium to condense in the condenser.

There are two known techniques which utilize the heat pump principle in connection with a composting reactor. In DE A1 3 844 700, a heat pump is used for transferring heat from the exit air of the composting reactor to its supply air. This is done by passing the exit air into a heat exchanger with a built-in evaporator. The heat pump gives off the collected heat energy (in the evaporator) in a condenser, which is incorporated in a heat exchanger that heats the supply air to the reactor. This technique just employs the heat pump principle for heating the supply air to the composting reactor.

The heat pump principle is also used in DE A1 3 043 062, where the composting reactor is used as an evaporator, the composting air as a working medium, and where the condenser is incorporated in a heat exchanger. In this process the process heat, collected via the heat exchanger, can be utilized for heating. Only the condensate is recycled to the composting mass.

The Institute of Agricultural Engineering at the Danish Royal Veterinary and Agricultural University, communication No. 43, December 1983, Thostrup, Per and Berthelsen Leif, "Komposteringsvarme fra fast staldgødning" (Composting heat from solid farmyard manure), pages 46-51, in particular pages 48-49 and fig. 6.2, discloses a composting system for solid farmyard manure. The farmyard manure is aerated by injecting air through the slotted floor at the bottom of the reactor. Most of the air is recirculated inside the reactor by a fan, while about 10 % is withdrawn. This withdrawn air is cooled in an air washer by circulating the air through some air washer material where it meets some water, which is recirculated by a pump. The heated water is collected in a sump, where the energy is conveyed via a heat exchanger to the consumer. Fresh air is added by injecting it through the manure. This system comprises no recirculation of air from the air washer to the reactor, and thus no efficient control of the composting air.

The object of the invention is to provide a process for controlling the composting air in a composting system of the type mentioned in the opening paragraph, which combines control of the composting process with collection of ammonia from the composting air and utilization of the composting heat, thereby obtaining an efficient process control which ensures a very high degradation rate which

leads to a considerable generation of composting heat and evaporation of ammonia.

The composting heat and the ammonia are utilized/collected in an extremely rational manner, as the utilization and the collection are integrated in the process control.

This is obtained according to the invention by using a process for controlling the composting air in a composting system of the type mentioned in the opening paragraph, which is characterized in that the composting air is sucked out of the composting reactor, is pressed into an air washer which cools the composting air with washing water, following which part of the composting air is withdrawn and the rest of the composting air is throttled, is mixed with fresh air and is recirculated to the composting reactor.

This results in an efficient control of the composting process in the composting reactor by virtue of a direct control of the temperature and composition of the inlet air of the reactor and by direct control of the temperature of the exit air. The temperature of the supply air is controlled by regulating the pressure and the exit temperature in the air washer and by regulating the supply of fresh air. The temperature of the exit air of the reactor is controlled by regulating the air performance of the air pump.

This efficient control ensures supply of oxygen for the composting and removal of precisely the amount of water vapour from the composting reactor which ensures a constant dry matter content in the organic material during composting. Thus, the degradation of the dry matter in the organic material is compensated by removing

a corresponding part of the water content in the organic material and the process water which is formed by the degradation of the dry matter.

The removal of the water from the organic material is closely linked with the utilization of the composting heat, as the composting heat is primarily used for evaporation of water in the reactor, which is given off again by condensation in the air washer. The magnitude of the condensation in the air washer depends on the required state in the supply air of the reactor. Recirculation of the greater part of the composting air after the condensation minimizes the loss of energy from the air circuit, as the only direct loss is via the exit air from the heat pump circuit.

By far the greatest part of the composting energy is transferred via the water vapour in the composting air to the washing water, which transfers the energy to a heating system via a heat exchanger. There is no direct loss of energy in connection with the transfers, but the temperature drops for each transfer. An increase in the pressure in the air washer increases the condensation temperature and results in a correspondingly higher temperature in washing water and heating system. The exit temperature of the composting air from the air washer is regulated by the flow of the washing water.

The air pump creates a positive pressure in the air washer, and it sucks composting air, including water vapour, out of the composting reactor. The suction creates a negative pressure which increases the possible content of water vapour and thus energy in the composting air. The composting air is compressed from an absolute pressure of 0.5 to 0.99 bar, preferably 0.96 bar, in the reactor to an absolute pressure of 1.1 to 3 bars,

preferably 1.3 to 2.2 bars in the air washer. The energy consumption of the air pump increased with an increasing negative and positive pressure. This energy consumption is related to the advantages of the negative pressure in the reactor and the positive pressure in the air washer, respectively.

The composting air contains ammonia, and an excess of ammonia-containing washing water is currently formed because of the condensation of the water vapour in the air washer. This means that, in practice, the washing water consists of ammonia-containing condensed water vapour, and the excess of ammonia-containing washing water is withdrawn. Since the greater part of the ammonia in the composting air is either captured in the washing water or is recirculated to the composting reactor, the loss of ammonia from the circuit via the exit air of the circuit is limited.

10 to 50 % by volume, preferably 15 to 25 % by volume, of the composting air is withdrawn after the air washer and replaced by fresh air prior to recirculation to the composting reactor.

In a special embodiment of the process, the withdrawn composting air is passed through one or more serially connected containers containing composted organic material. This ensures that the withdrawn composting air is cleaned of ammonia, but also of other malodorous compounds, as the containers serve as biofilters. The nutrient content of the composting air is hereby bound in the compost which is used as a soil conditiner.

In a second embodiment of the process, the withdrawn composting air is used for stripping the ammonia from the ammonia-containing condensate in an ammonia washer, and

then the air is passed through the biofilter consisting of one or more serially connected containers containing composted organic material. This process leads to a reduction in the content of ammonia in the condensate and an increase of nutrient in the compost.

In a third embodiment, stripping is made particularly efficient by adding a base to the condensate before the ammonia washer, and all ammonia in the condensate is hereby transferred to the withdrawn composting air.

In a fourth embodiment of the process, fresh air is passed through the ammonia washer before it is mixed with the recirculated composting air or is passed through the biofilter. Fresh air does not contain ammonia and will therefore be extremely efficient to strip the ammonia from the condensate and then pass the ammonia back to the composting reactor or through the biofilter. When the fresh air is passed through the ammonia washer before the composting reactor, it is moreover ensured that the heat energy of the ammonia-containing condensate is transferred to the fresh air and is thereby recirculated to the composting reactor.

The invention moreover provides a composting system for use in the process of the invention. The composting system is characterized in that it comprises a composting reactor, an air pump, an air washer, a throttle valve and a liquid circuit consisting of the air washer and a heat exchanger.

A particularly good effect is obtained when the invention is used in connection with a composting reactor for solid organic material which employs a vertical composting profile and counterflow aeration. In a composting reactor having a vertical composting profile, fresh organic

material is added from above, and compost is taken out at the bottom of the reactor. The actual composting profile consists of fresh material at the top, an active zone in the centre and compost at the bottom. Thanks to the counterflow aeration, the air flow is directed oppositely to the movement of the organic material. This means that the relatively cool supply air is admitted at the bottom of the reactor, and the heated exit air is withdrawn at the top of the reactor. This approach provides efficient aeration and utilization of the composting air, and it reduces the requirement with respect to the air performance of the air pump and thus reduces the energy consumption of the air pump.

In a special embodiment of the composting system, the composting reactor with vertical composting profile and counterblow aeration is an insulated receptacle with gates at the ends, which comprises a plurality of serially connected containers. The composting reactor may moreover comprise several rows of serially connected containers which are stacked on top of each other, thereby providing a compact reactor with a minimum heat loss.

The individual containers consist of a closed receptacle having an opening in the bottom for admission of air and an opening at the top for withdrawal of air. The sides of the containers have an inclination of 10 to 30°, preferably 20°. This angle is to prevent formation of air channels along the sides and thus disuniform aeration of the organic material.

Air is admitted to the individual container at the bottom and withdrawn from it at the top. The air is passed through the rows of containers so that the supply air to the reactor is first passed through the containers with

the oldest organic material and is withdrawn from the containers with the youngest organic material.

With this structure of the reactor, the vertical composting profile is divided into several layers - corresponding to the number of containers in series connection. When the profile is thus divided into several thin layers, the compression of the manure is reduced owing to the dead weight of the manure. In case of large layer thicknesses, the dead weight of the manure presses the air out of the lowermost part of the manure layer. This increases the counterpressure in the manure, which causes composting air to flow in air channels along the sides of the reactor.

The structure moreover results in an increased thickness of the composting layer, and it is thus possible to obtain a particularly great temperature gradient in the organic material, so that the temperature in the oldest organic material is about 25 °C and the temperature in the youngest organic material is about 60 °C. With this temperature gradient, the readily transformable organic material will be degraded thermophilically (45 to 60 °C), the non-readily transformable organic material will be degraded mesophilically (30 to 45 °C), and the ammonia in the recirculated composting air is nitrified at 25 to 30 °C.

Expedient embodiments of the invention are defined in the dependent claims.

As mentioned, the invention also concerns a use of the composting system and the process. This use is defined in claim 17.

The invention will be described more fully below with reference to the drawing, in which

fig. 1a shows a diagram of the composting system of the invention with air circuit and liquid circuit;

fig. 1b shows a special embodiment of the composting system of the invention;

fig. 1c shows a second special embodiment of the composting system of the invention;

fig. 2 shows the composting reactor with containers;

fig. 3 shows a container in section, and

fig. 4 shows possible uses of the composting system.

Fig. 1a shows a diagram of the composting air circuit (solid line) and the liquid circuit (dashed line). Basically, the diagram may be described using the terminology of heat pumps. The composting reactor 101 is the evaporator, the air washer 121 is the condenser, and the composting air is the working medium.

The organic material to be composted is placed in the composting reactor 101. The composting air is sucked out of the reactor at 102 by means of an air pump, e.g. a compressor, 111, and is pressed into an air washer 121 at 122. The composting air is cooled in the air washer with washing water, which is admitted at 124 and trickles down through the washing material 127. The cooled composting air is discharged from the air washer at 123, following which part of the composting air is withdrawn by the valve 131, and the rest is throttled in a throttle valve

132, is mixed with fresh air admitted at 133, and is recirculated to the reactor at 103.

The ammonia-containing washing water is collected at the bottom of the air washer 121, and the excess of ammonia-containing washing water is withdrawn at 126 and passed to a collecting container 141. The rest of the washing water is discharged from the air washer at 125 by a pump 161 and is supplied to the heat exchanger 151 at 152, where the heat energy is transferred. The washing water is then recirculated to the air washer, being discharged at 153 and supplied to the air washer at 124. The numerals 154 and 155 respectively illustrate outlet from and inlet to the heat exchanger of the medium to which the heat energy is transferred.

Fig. 1b shows a special embodiment of the composting system. This system differs from the system of fig. 1a in that the withdrawn composting air from the air washer is passed through one or more serially connected containers 201 containing composted organic material. The figure also shows how the ammonia-containing condensate, which is withdrawn at 126, is stripped in an ammonia washer 171 by the withdrawn composting air, which is introduced into the ammonia washer at 172, following which the air is withdrawn at 175 and is passed through one or more serially connected containers 201 containing composted organic material. The condensate is discharged at 174. A base may be added to the condensate at 181.

Fig. 1c shows a second special embodiment of the composting system. In this system, the ammonia-containing condensate is stripped in an ammonia washer 171 by fresh air, which is admitted at 176. The exit air from the ammonia washer is withdrawn partly at 173 and is passed to the composting reactor 101, and partly at 175 where it is

passed through one or more serially connected containers 201 containing composted organic material. The condensate is discharged at 174.

Fig. 2 shows an alternative embodiment of the composting reactor. The composting reactor consists of an insulated receptacle with gates 204 and 205 at the ends, and the reactor comprises a plurality of containers which are serially connected 201a1, -2, -3, -4, -5, 201b1, -2, -3, -4, -5, and 201c1, -2, -3, -4, -5. Supply and withdrawal of organic material are performed by removing a container column containing composted organic material through the gate 204 and then inserting a container column containing fresh organic material into the reactor through the gate 205.

The composting air is introduced into the reactor at 203 and is supplied to the containers 201a5, 201b5 and 201c5 at the bottom. The composting air is passed from the top of the containers to the next container in the row 201a4, 201b4 and 201c4, where it is again introduced at the bottom of the containers. Having passed the container arrangement, the composting air is again withdrawn at 202.

Fig. 3 shows a single container 301 in section. The container is a closed receptacle with an opening 303 at the bottom for admission of composting air and an opening 302 at the top for withdrawal of composting air. The sides of the container have an inclination A.

Fig. 4 shows the possible uses of the composting system of the invention.

The operation of a composting system of the invention will be described below by way of an example. All sizes

are just illustrative and are not to be taken as a restriction in the scope of the invention.

Example

This examples shows how the composting air is controlled and thus changes its state when it circulates in the composting system. Then, the yield from the composting of solid cow manure from 50 milking cows is calculated.

The state of the composting air is described by the parameters: Absolute pressure (P), temperature (T), specific water content (X) and energy content (I). It is assumed that the supply air to the reactor is characterised by an absolute pressure P = 0.99 bar, a temperature T = 37 ^{o}C, a water content X = 40 g/kg of DA (DA = dry air) and an energy content I = 140 kJ/kg of DA. In the reactor, the air is heated and water evaporates as a consequence of the composting process. A compressor regulates the air flow through the reactor. Because of the composting the temperature of the air increases by 20 ^{o}C, the water content by 120 g/kg of DA and the energy content by 320 kJ/kg of DA in the reactor. As a result, the exit air from the reactor is characterized by P = 0.96 bar, T = 60 ^{o}C, X = 160 g/kg of DA and I = 460 kJ/kg of DA.

A compressor sucks the exit air out and compresses it. The compressor adds energy to the air in the compression, so that the supply air to the air washer is characterized by P = 2.0 bars, T = 80 ^{o}C, X = 160 g/kg of DA and I = 480 kJ/kg of DA.

The condensing of water vapour is controlled in the air washer via the pressure and cooling with washing water.

The size of the pressure is regulated by the throttle valve and the cooling by the size of the washing water flow through the air washer material. Cooling and condensing reduces the temperature of the air by 25 ^{o}C, the water content by 110 g/kg of DA and the energy content by 300 kJ/kg of DA. The excess washing water of 110 g/kg of DA is withdrawn from the air washer and passed into a collecting container. The air is discharged from the air washer, and it is now characterized by P = 2.0 bars, T = 55 ^{o}C, X = 50 g/kg of DA and I = 180 kJ/kg of DA.

Part of the air is exchanged after the air washer to discharge carbon dioxide and to add oxygen with fresh air, so that the content of oxygen is minimum 14 %. 25 % of the exit air from the air washer is discharged, and 75 % is throttled with the throttle valve. After the throttle valve, the air is characterized by P = 0.99 bar, T = 40 ^{o}C, X = 52 g/kg of DA and I = 170 kJ/kg of DA. The small negative pressure sucks fresh air in. The amount of fresh air is controlled via the amount of air which is discharged. The mixture of fresh air and throttled air is the supply air to the reactor, and the air circuit is thus completed.

The washing water is passed through the air washer according to the counterflow principle. The washing water is 50 ^{o}C when it enters the air washer, and its temperature rises to 65 ^{o}C after the passage of the washing material. This temperature is 5 ^{o}C higher than the exit air from the reactor, and this is possible owing to the high pressure in the air washer which means that the condensation begins at 70 ^{o}C. The washing water is pumped out of the air washer and is cooled in the heat exchanger to 50 ^{o}C by water from a heating system. The water in the heating system can thus have a service temperature of 60 ^{o}C.

When composting cow manure containing 30 % dry matter, 50 % of the dry matter is degraded. During composting of 1 kg of cow manure the air is to discharge 440 g of water, and 3.7 kg of DA therefore have to be blown through the reactor. 410 g of washing water having an ammonia content of 0.5 % (corresponds to the ammonia content in urine) are withdrawn from the air washer, and 1.1 MJ are transferred to the heating system (minus loss through insulation). An average Danish cowhouse with 50 milking cows produces 2700 kg of cow manure containing 30 % dry matter (including dry matter regulating supply of straw) on a daily basis. This manure is turned into 1100 litres of ammonia-containing washing water, 1400 kg of compost and a continuous heating power of 34 kW in a composting system of the invention.

P a t e n t C l a i m s :

1. A process for controlling the composting air in a composting system comprising an aerobic composting reactor (101), c h a r a c t e r i z e d in that the composting air is sucked out of the composting reactor (101), is pressed into a an air washer (121) which cools the composting air with washing water, following which part of the composting air is withdrawn and the rest of the composting air is throttled, is mixed with fresh air and is recirculated to the composting reactor (101).

2. A process according to claim 1, c h a r a c t e r i z e d in that the withdrawn composting air is passed through one or more serially connected containers (201) containing composted organic material.

3. A process according to claim 1, c h a r a c t e r i z e d in that ammonia-containing condensate is continuously withdrawn from the air washer.

4. A process according to claim 3, c h a r a c t e r i z e d in that the ammonia-containing condensate is stripped in an ammonia washer (171) with the exit air, which is then passed through one or more serially-connected containers (201) containing composted organic material.

5. A process according to claim 4, c h a r a c t e r i z e d in that a base (181) is added to the condensate before the ammonia washer (171).

6. A process according to claim 3, c h a r a c t e r i z e d in that the ammonia-containing condensate is stripped with fresh air in an ammonia washer, which is

then passed through one or more serially connected containers (201) containing composted organic material or is mixed with the recirculated composting air.

7. A process according to claim 1, c h a r a c t e r i z e d in that 10 to 50 % by volume, preferably 15 to 25 % by volume of the composting air is withdrawn after the air washer (121) and is replaced by fresh air before recirculation to the composting reactor (101).

8. A process according to claim 1, c h a r a c t e r i z e d in that a compressor (111) sucks the composting air out of the composting reactor (101) and presses it into the air washer (121).

9. A process according to claim 1 or 8, c h a r a c t e r i z e d in that the composting air is compressed from an absolute pressure of 0.5 to 0.99 bar, preferably 0.96 bar, in the reactor to an absolute pressure of 1.1 to 3 bars, preferably 1.3 to 2.2 bars in the air washer (121).

10. A process according to claim 1, c h a r a c t e r z e d in that the washing water flow regulates the exit temperature of the composting air from the air washer.

11. A process according to claim 1, c h a r a c t e r i z e d in that the washing water is cooled in a heat exchanger (151) which transfers the heat energy to a heating system, and the washing water is then recirculated to the air washer.

12. A composting system for use in the performance of the process of claims 1-11, c h a r a c t e r i z e d in that it comprises an air circuit consisting of a composting reactor (101), an air pump (111), an air washer

(121), a throttle valve (132) and a liquid circuit consisting of the air washer and a heat exchanger (151).

13. A composting system according to claim 12, c h a r a c t e r i z e d in that the composting reactor (101) has a vertical composting profile and counterflow aeration.

14. A composting system according to claim 12 or 13, c h a r a c t e r i z e d in that the composting reactor (101) is an insulated receptacle having gates at the ends and a plurality of serially connected containers (201).

15. A composting system according to claim 14, c h a r a c t e r i z e d in that the composting reactor comprises several rows of serially connected containers (201).

16. A composting system according to claim 14 or 15, c h a r a c t e r i z e d in that each individual container is a closed receptacle having an opening at the bottom (202) for admission of air and an opening at the top (203) for withdrawal of air.

17. A composting system according to claims 14-16, c h a r a c t e r i z e d in that the sides of the container have an inclination A of 10 to 30^{o}, preferably 20^{o}.

18. Use of a composting system and a process according to any one of the preceding claims for the composting of organic material, preferably solid organic material having a dry matter content of 20 to 30 %, with collection of ammonia containing condensate and utilization of composting energy.

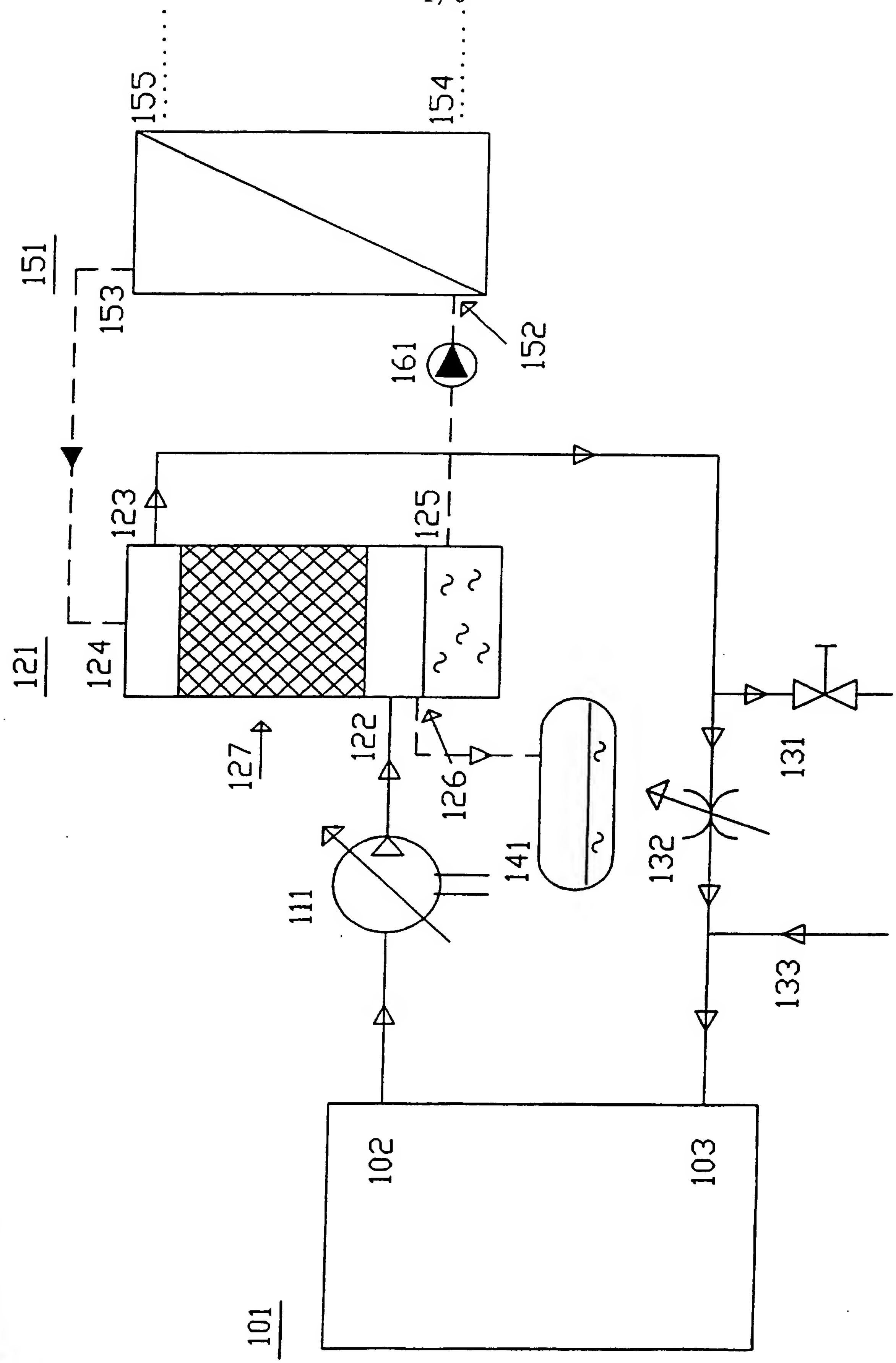
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Fig 1a

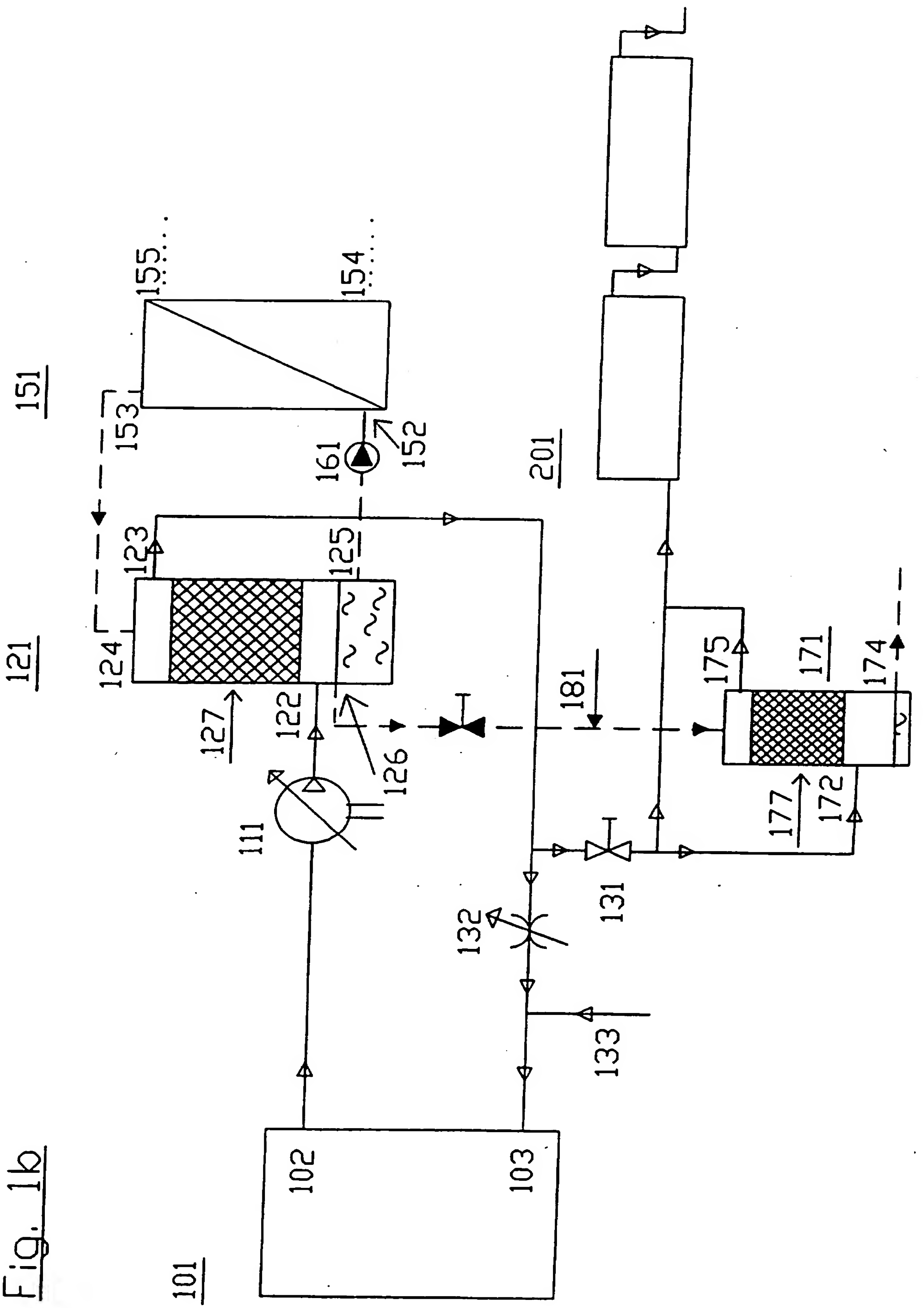
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Fig. 1b

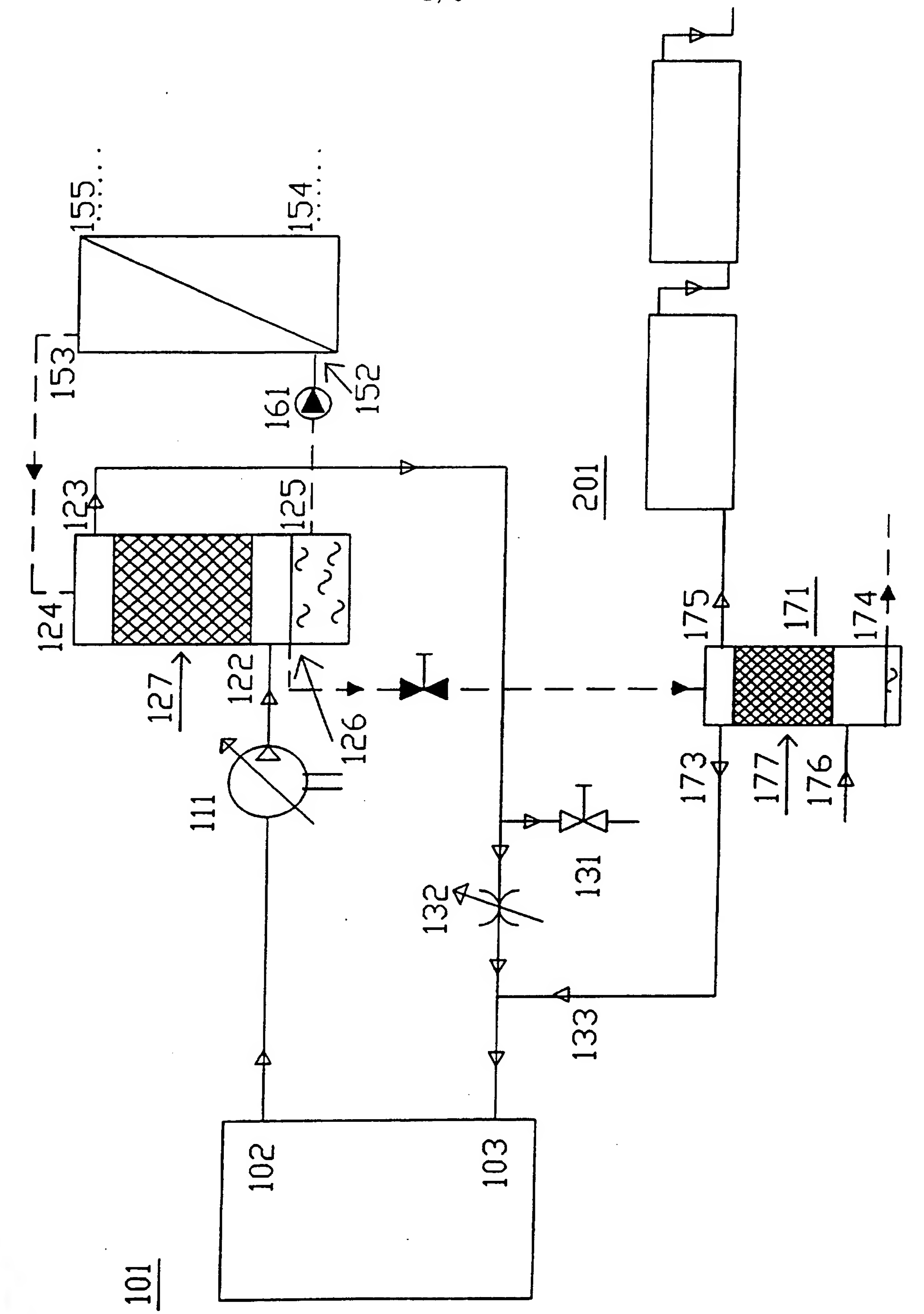
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Fig. 1c

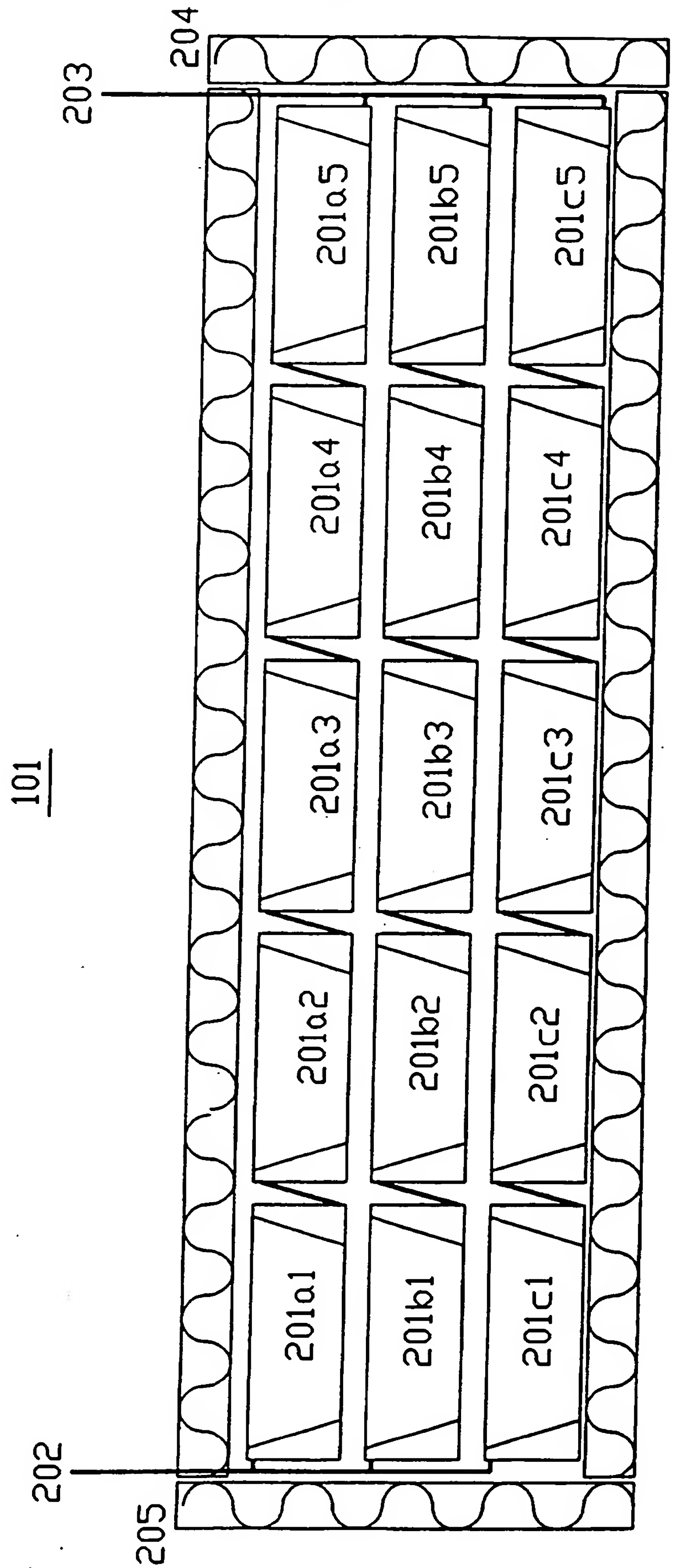
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Fig. 2

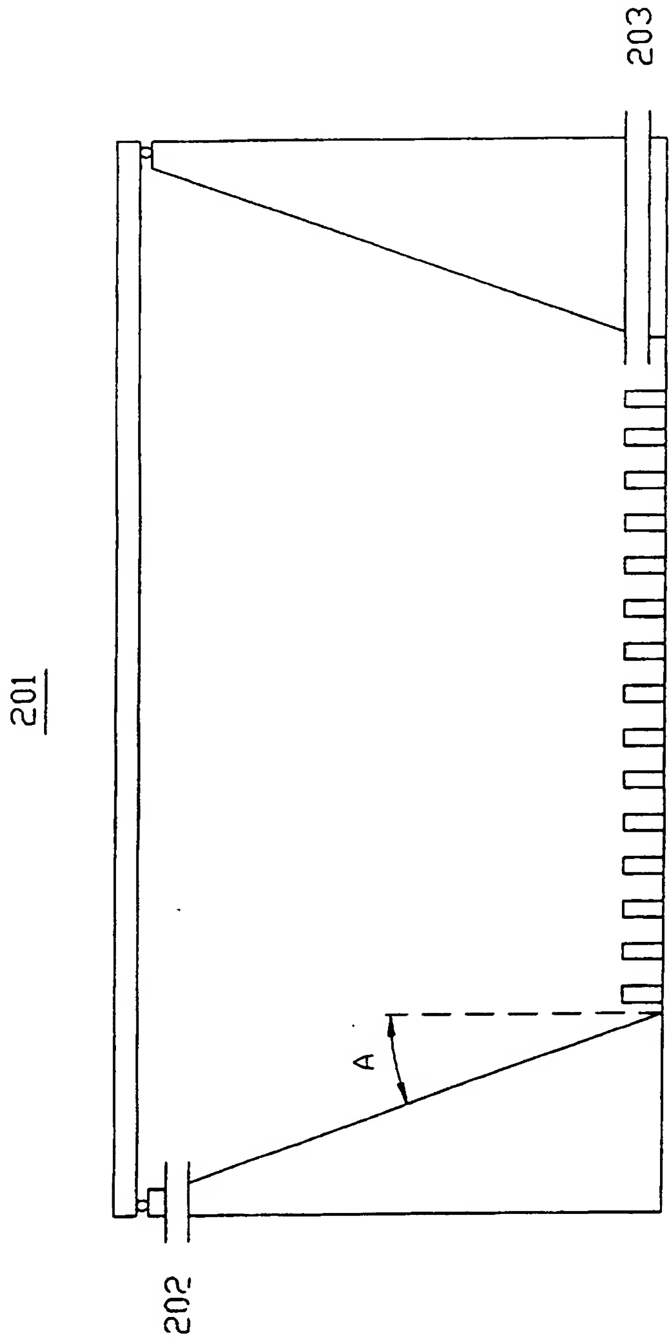
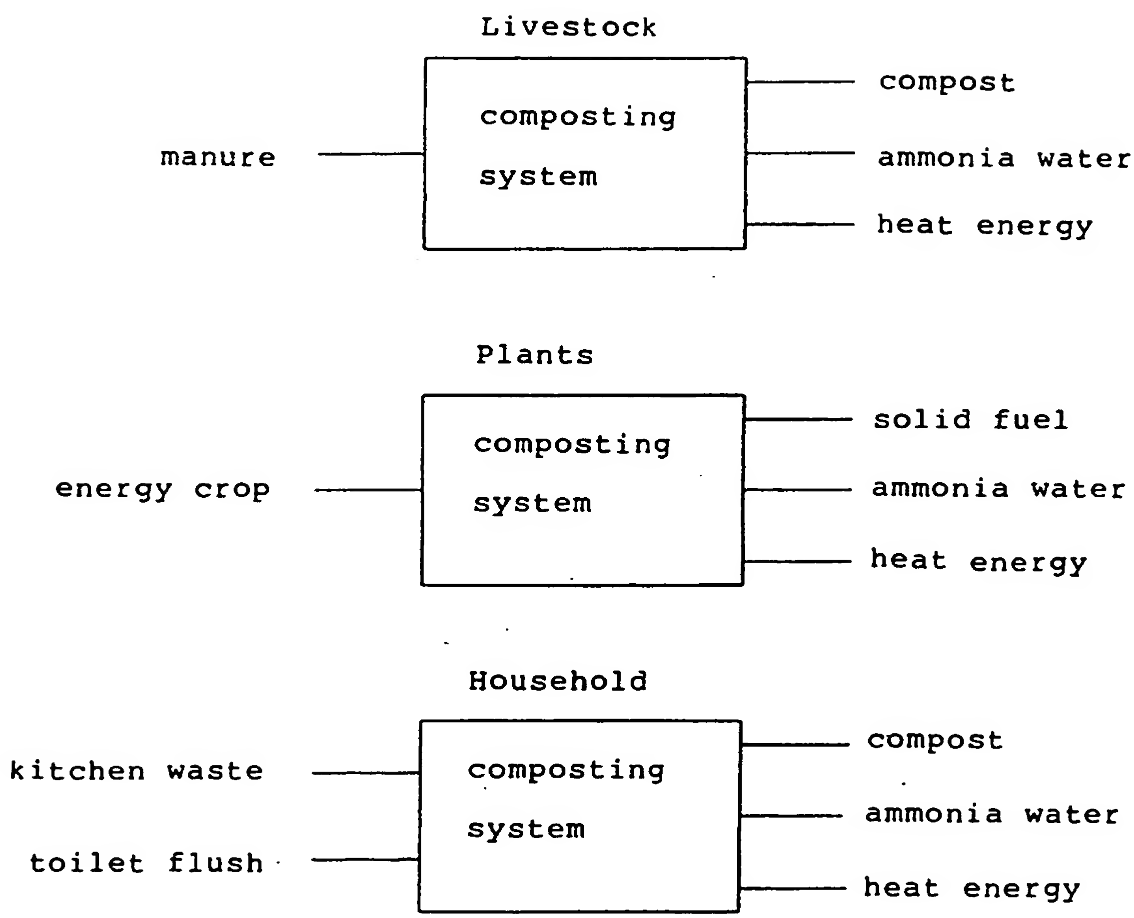


Fig. 3

Fig. 4

USE OF THE COMPOSTING SYSTEM



INTERNATIONAL SEARCH REPORT

International application No.
PCT/DK 95/00356

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: C05F 17/00, C05F 17/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: C05F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI, CLAIMS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 9323351 A1 (GRABBE, KLAUS), 25 November 1993 (25.11.93), page 5, line 7 - line 11, claim 13	1-3,7,18
Y		8-10
A		4-6,11-17
	--	
A	EP 0244391 A2 (VOEST-ALPINE AKTIENGESELLSCHAFT), 4 November 1987 (04.11.87), claims 1-10, abstract, the figure	1,2,3
Y	claims 1-10, the figure	8-10
	--	

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
8 December 1995	18-12-1995

Name and mailing address of the ISA/	Authorized officer
Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Ingela Flink Telephone No. +46 8 782 25 00

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0434159 A1 (INTERCHAMP B.V.), 26 June 1991 (26.06.91), column 5, line 40 - line 54; column 6, line 5 - line 19, figure 2 --	1,3,7,10,12, 18
A	DE 2558255 A1 (KNEER, FRANZ XAVER), 7 July 1977 (07.07.77), page 7, line 20 - line 24; page 8, line 31 - page 9, line 32, the figure --	1,3,8,9,12, 13,18
A	FR 998962 A (MM. CHARLES GRUE ET AL), 25 January 1952 (25.01.52), the figure -- --------	13-15

INTERNATIONAL SEARCH REPORT

International application No.
PCT/[illegible] 95/00356

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
WO-A1-	9323351	25/11/93	NONE		
EP-A2-	0244391	04/11/87	AT-B-	392960	25/07/91
EP-A1-	0434159	26/06/91	NL-A-	8903072	01/07/91
DE-A1-	2558255	07/07/77	NONE		
FR-A-	998962	25/01/52	NONE		